100 YEARS OF COTTON PRODUCTION, HARVESTING, AND GINNING SYSTEMS ENGINEERING: 1907–2007

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ABSTRACT. *The American Society of Agricultural and Biological Engineers (ASABE) celebrated its centennial year during 2007. As part of the ASABE centennial, the authors were asked to describe agricultural engineering accomplishments in U.S. cotton production, harvesting, and ginning over the past 100 years. The U.S. cotton industry has not existed in a vacuum but has always been influenced by social, political, and economic forces as well as engineering developments throughout its history. However, for the purpose of this article, the authors concentrated solely on describing engineering developments and practices in cotton production, harvesting, and ginning and their influence on each other. In order to describe engineering developments from 1907 forward, it was necessary to lay some basic groundwork on what occurred prior to the last 100 years in the U.S. cotton industry.*

Keywords. *Cotton ginning, Cotton harvesting, Cotton picking, Cotton production, History.*

Cotton production first began in the U.S. in the early 1600s when settlers imported seed with the hopes of developing another source of cotton for the English textile industry. Most of the cotton was grown on small family farms and was very labor intensive. The man hours required to produce a bale of cotton in the year 1800 has been estimated at 601 hours; by 2007, the man hours required to produce a bale of cotton had shrunk to three (Cline, 2006). The story of the 598 lost man hours is a story of change and innovation brought about by engineering and innovation.

As cotton acreage increased early in our country's history, the demand for labor continued to increase, which resulted in the plantation system of cotton production that lasted until the Civil War. After the Civil War, much of the labor requirement was met through the sharecropper system of farming. The main source of farm power was through the use of mules and horses. The number of oxen, mules, and horses on farms in the U.S. in 1910 has been estimated at 20 million. The major activities requiring a lot of human labor were weed control and harvest. This did not change significantly until after 1940.

Cotton fibers must be removed from the seed by some type of machine before textile manufacturing. The belief that before Eli Whitney cotton fiber was removed from the seed by hand is quite likely a misconception. There is strong evidence that simple machines have always been used to "gin" cotton, and these early machines were a type of roller gin (Lakwete, 2003). The roller gins used in early years generally consisted of two narrow-diameter rollers joined by worm gears that rotated simultaneously in opposite directions when manually cranked with a single handle. These types of gins are commonly known today as churkha gins (fig. 1). The rollers, generally about 30.5 cm (12 in.) long, were mounted in a rigid frame that forced them to remain in contact as they were turned by a single operator. As the rollers rotated, the operator fed seed cotton (seed with the cotton fiber still attached) to one side of the rollers. The rollers pulled the fiber through but restrained the seed, which dropped off after the fibers were removed (ginned). These gins could probably separate about 2.3 kg (5 lbs) of cotton fiber from seed in a day. Variations and improvements in power and speed on this basic gin design were used to gin American cotton from 1607 to the 1790s and beyond. These gins worked best on Sea Island cotton (*Gossypium barbadense*), which has relatively weak lint and seed attachment forces, but were not as effective on the more predominant upland cotton (*Gossypium hirsutum*), with relatively strong lint and seed attachment forces.

For an excellent discussion of the development of the U.S. cotton ginning industry from 1607 to about 1870, we recommend *Inventing the Cotton Gin: Machine and Myth in Antebellum America* by Dr. Angela Lakwete. It suffices for our purposes here to say that it is well known that Eli Whitney filed a patent in 1794 for a wire- or spike-tooth gin that greatly increased ginning rates over the churkha-type gins then being used. At its core, Whitney's gin consisted of a round wooden log that had sharpened spikes driven into it with which to pull the cotton fiber off of the seed in a batch process. What is not as well known is that Henry Odgen Holmes filed a patent in 1796 for what he called a "saw-gin". Figure 2 shows a cross-section of Holmes' gin, which has all of the basic mechanical and functional elements of saw gins used today. Holmes' basic saw-gin design is what Whitney actually manufactured and is popularly given credit for inventing.

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Figure 1. An example of a churkha gin.

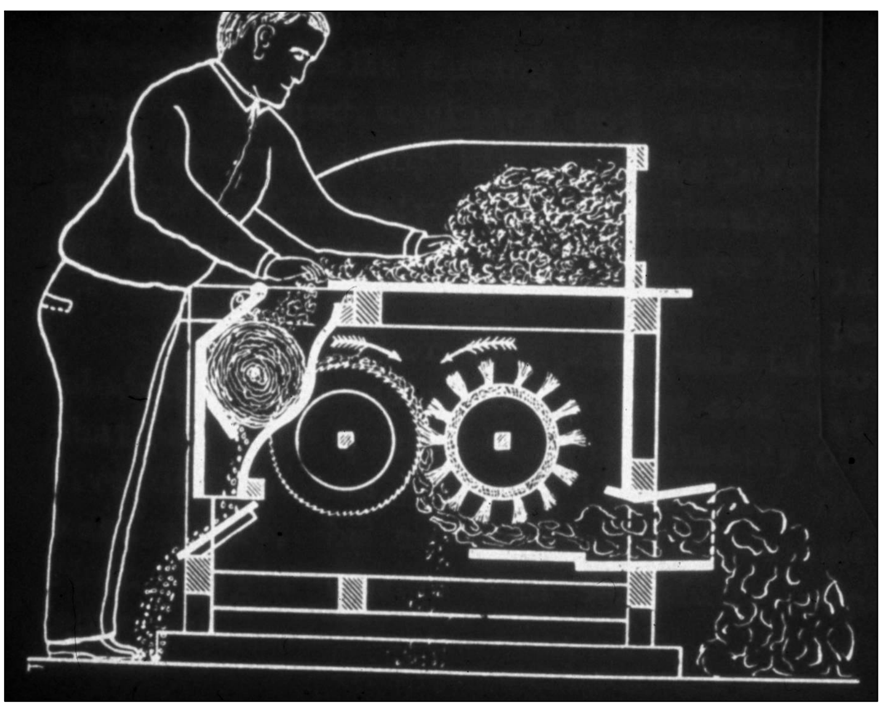


Figure 2. Cross-section of Henry Ogden Holmes' saw-gin.

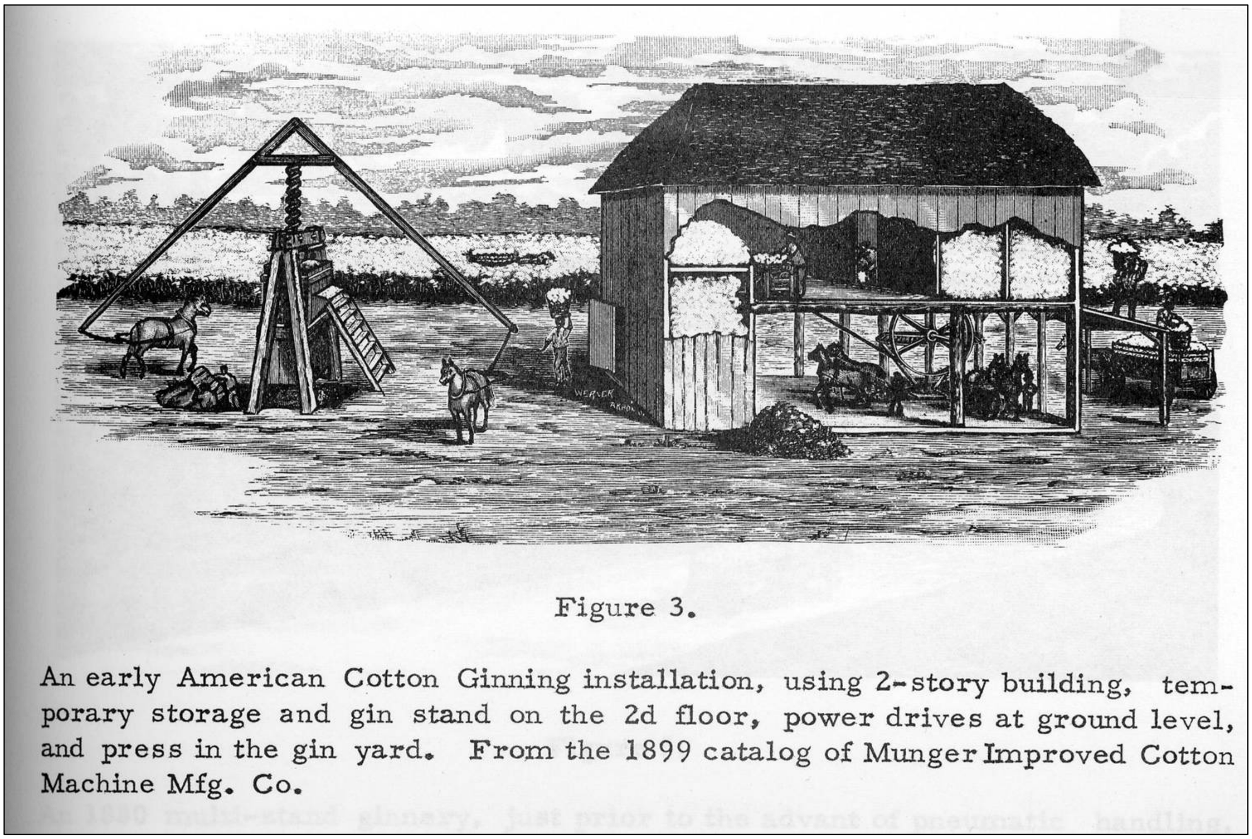


Figure 3. Early American saw gin system.

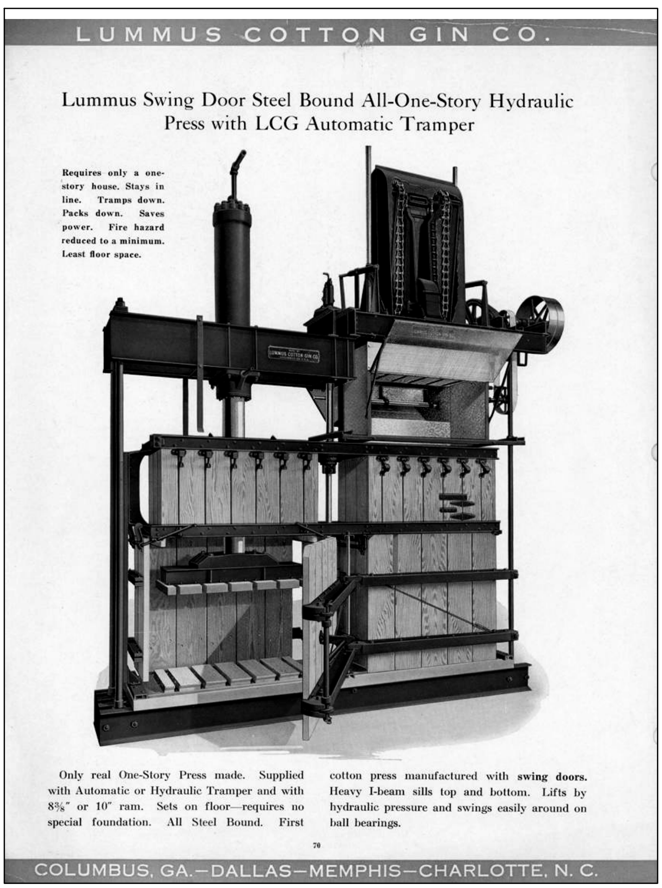


Figure 4. An early double box press with hydraulic ram.

During the next few decades following 1796, the saw-gin was made part of a ginning system that generally included a two-story building with the saw-gin stand on the second floor (fig. 3). A first-floor walkway was where harnessed animals provided power through a simple cogwheel/flat belt drive system. The building provided storage for seed cotton waiting to be ginned and a blow room to store ginned lint prior to pressing into bales. Early presses were animal-powered, single-box, wooden screw presses located separately from the main building (fig. 3) that later evolved into double-box presses with some type of mechanical loading tramper over one box and a steam or hydraulic ram over the second box for final bale pressing (fig. 4). Seed cotton and ginned lint may have been moved through the system manually or by various simple designs of pneumatic or mechanical conveyance.

By 1907, there were approximately 27,600 cotton ginning plants in the U.S. that processed about 11,100,000 bales of cotton produced on 12,441,296 hectares (30,730,000 acres), with an average yield of 193.9 kg ha^{-1} (173 lbs $acre^{-1}$). The next 100 years would see major changes in production methods, average cotton yield, gin numbers, as well as in the design of gin plants across America.

A Century of Agricultural Engineering

Cotton Harvester Development

While mechanization of agriculture made many advances during the 18th and 19th centuries, it was not until the introduction of the row-crop tractor in the 1920s that major engineering advances were made in the mechanization of cotton production and harvesting. The introduction of a reliable and transportable power source, coupled with the advances made during the 19th century in tillage tools, allowed the cotton farmer to be able to produce more than could be hand harvested within a reasonable time frame. As harvesting the seed cotton became a major obstacle to the ability to increase acreage, significant efforts were devoted to developing a mechanical method of harvesting cotton.

During the 1920s and 1930s, the number of patents issued for mechanical harvesting equipment greatly increased. Inventors throughout the cotton belt experimented with a variety of different methods to mechanically harvest cotton. Some of these included: pneumatic harvesters that used suction or air blast to remove seed cotton from the bolls; electrical cotton harvesters that used a statically charged belt or finger to attract the lint and remove the seed cotton from the boll; a thresher-type harvester that cut down the plant near the surface of the ground and took the entire plant into the machine, where the seed cotton was separated from the vegetable material using spindles; a stripper-type harvester that combed the plant with teeth or drew it between stationary slots or teeth; and the most popular picker or spindle-type machine was designed to pick the open cotton from the bolls using spindles, fingers, or prongs, without injuring the plant's foliage and unopened bolls. Their lack of success reinforced the belief that cotton would always be picked by hand. For almost a hundred years, it seemed, a successful cotton picker was always just around the corner.

One company founded in 1910, the Price-Campbell Cotton Picker Corp., developed a spindle-type cotton picker that used rotating barbed rods to twist the lint from the boll through the side of the plant. This was based on the earlier work of Angus Campbell of Chicago, Illinois, an agricultural engineer who saw the tedious process of picking cotton. Beginning in the 1880s, Campbell made annual trips to Texas to test the latest model mechanical picker. He obtained a patent in 1895 on a spindle design that has proven to be the basic principle for the successful modern cotton picker used today. Progress in the equipment development was very slow for several reasons, both mechanical and social. In 1924, International Harvester Co. (IHC) began a rejuvenated effort to develop the spindle-type cotton picker using the purchased Price-Campbell patents. That same year, IHC demonstrated a one-row, self-propelled harvester using four picking heads that was tested near Dallas, Texas (Hagen, 1951).

In 1926, Hiram M. Berry of Greenville, Mississippi, field tested a picker with rotating barbed spindles with a reversed spindle rotation for doffing. Both Allis-Chalmers and Deere & Co. were very interested in the design and felt that it would out perform the IHC harvester (Jensen, 2001). There were other designs, such as the 1928 Hamme Picker from Oxford, North Carolina, which used long rotating rods that picked from the top of the plant. The Meyercord picker of 1929 used double-hooked, corkscrew-type picking fingers that protruded 0.95 cm (3/8 in.) from their mountings. Both types of pickers were manufactured and operated for several years, but never gained full commercial acceptance.

By the mid-1930s, the widespread use of mechanical cotton harvesters seemed imminent and inevitable. In 1936, the Rust brothers' cotton picker machine received a public trial at the Delta Experiment Station near Leland, Mississippi. Although the Rust picker was not perfected, it did pick cotton, and it picked it well. The machine produced a sensation, sending a shudder throughout the region. Activists provoked the fear that the Rust brothers' mechanical picker would destroy the South's sharecropping system and, during the Great Depression, throw millions of people out of work. Most agriculturalists believed that the mechanization of cotton would be a gradual process competing with the availability and cost of farm labor in the Depression (Holley, 2003).

In 1942, IHC made a public announcement that a mechanical cotton picker was going to be put into production. In 1944, IHC built 75 machines that were designed to be mounted on the model M Farmall tractor with a two-fan conveyor system and two high drum picker units. In 1945, to reduce costs, a single-fan conveyor system with two short picker drums on the same side of the row was mounted on a model B Farmall tractor. Later a two-row machine was developed and mounted on the bigger model M Farmall tractor. The loss of a cheap supply of labor due to World War II coupled with the desire to harvest the cotton crop in a shorter period greatly encouraged the farmer's acceptance of the machine.

Other farm machinery companies soon followed with introductions of cotton pickers and strippers. Deere & Company of Moline, Illinois, had experimented with stripper-type harvesters and variations of the spindle idea, but discontinued these experiments in 1931. In 1944, the company resumed work after buying the Berry patents, although Deere's machine incorporated its own innovative designs. Deere quickly regained the ground it had lost during the Depression. In 1950, Deere's Des Moines Works at Ankeny, Iowa, began production of a two-row picker that could do almost twice the harvesting job of one-row machines.

Allis Chalmers of Indianapolis, Indiana, provided financial resources and produced the Rust picker in 1944 using John Rust redesigns and patents. In late 1948, cotton farmers near Pine Bluff, Arkansas, suffered a labor shortage. Since cotton still stood unpicked in the fields at the end of the year, they invited Rust to demonstrate his picker. The demonstration was a success. Rust entered into an agreement with Ben Pearson, a Pine Bluff company known for archery equipment, to produce 100 machines for $1,000 each, paid in advance. All the machines were sold, and Ben Pearson hired Rust as a consultant and manufactured Rust cotton pickers (Holley, 2003).

At the ASAE meeting in Houston, Texas, in 1951, C. R. Hagen of IHC reported that 3,175 picking units were produced prior to 1951. In 1952, the U.S. Bureau of Census reported that a total of 11,959 spindle pickers were in the field and included Allis-Chalmers with 1,200, Ben Pearson with 1,500, Deere & Co. with 750 and IHC with the balance of 8,550 (Jenson, 2001). By 1955, over 25% of the cotton crop was machine harvested, 72% in 1963, and by 1965 the machine-harvested percentage was rapidly approaching 100%. The most rapid acceptance of mechanical harvesters occurred in the irrigated west and Mississippi Delta area, where spindle pickers were used, and the High Plains area of Texas and Oklahoma, where stripper-type harvesters were used.

The acceptance and performance of the spindle picker was greatly influenced by the conditions under which they operated. Cultural practices included raised beds for better access to the bolls; straight rows and uniformly placed plants that permitted easier operation and machine mobility; uniform row spacings that allowed the picker to pass without damage to unpicked plants, especially with multi-row equipment; improved weed control practices using both hand and chemical methods; improved fertilization and irrigation management to ensure maximum yield and avoid excess plant growth; and crop residue management that destroys stalks so they do not clog planters. New cotton varieties were being developed that were better suited to mechanical harvesting. Some of these traits included large bolls with strong attachment forces to the plant, short limbs and closer boll set, shorter seasoned and more determinate plants to reduce the number of harvester passes, open bolls without tight locked cotton for picker harvesting, and more storm-resistant varieties for stripper harvesting. These are a few of the production practices that have resulted from cotton harvest mechanization.

Stripper Harvester Development

Along with development of the mechanical picker, stripper harvesters were being developed. Stripper harvesters remove the cotton, bur, sticks, and any leaf that is left on the plant. This type of harvesting was first referred to as sledding, since one of the first stripping devices was a sled with fixed rods that removed plant material as the sled was pulled through the field. The material was pulled back into the wagon with a pitchfork and cleaned before ginning. Some of these horsedrawn sleds were used in Texas as early as 1914 (Colwick, 1965). This practice was limited to Texas and Oklahoma, where the plants were small and defoliated, which was usually accomplished by a freeze. In the 1920s, early improvements were made by replacing the fixed rods with a rotating pair of rods (Smith et al., 1935). These rolls had a fixed gap through which the plant would pass but not the cotton bolls. By 1926, the west Texas and Oklahoma crop was 1/3 hand picked, 1/3 hand snapped, and 1/3 sledded (Jensen, 2001). Hand-snapped cotton is the removal of the burr and seed cotton from the plant, as compared to hand picking, which removes only the seed cotton. Snapping is faster than picking.

In 1927, the Texas Agricultural Experiment Station at Lubbock demonstrated seven different harvesters. Harvest efficiency ranged from 72% to 97% for six of the strippers tested, and a Smith Houghton picker harvested 59% in two passes over the field (Jensen, 2001). It is easy to see how stripper-type harvesters became so popular in that region. Both International Harvester and John Deere built roll-type strippers that conveyed the cotton into a basket. John Deere developed the No. 30 cotton harvester, which used two steel rolls at a 30° angle rotating upward. A flighted elevator chain on each side of the rolls carried the crop to a hopper at the back. The John Deere No. 15, developed in the 1940s, was a two-row harvester with one steel stripping roll and one stationary bar per row.

The use of tractor-mounted roll-type strippers increased rapidly during World War II, and the gins were equipped with additional cleaning equipment to handle this type of cotton. In 1951, agricultural engineers in Oklahoma developed a stripping roll covered with brushes to reduce the amount of trash that accompanied the cotton. Improvements were made in the number of rows, the speed of operation, and conveyance of cotton to the hopper. Cotton strippers were more economical to own and operate, resulting in considerably lower costs per bale for harvesting. Field losses were lower than those from pickers; under ideal conditions, a stripper will harvest 99% of the cotton on the plant. However, since stripping was a once-over operation, harvesting had to be delayed until all the bolls were mature and any green material was desiccated, typically by frost. Weather losses become a concern, and storm-resistant varieties were developed to help minimize losses from cotton falling out of the burr.

Today, cotton strippers are predominantly used in the Texas, Oklahoma, and Kansas production regions. They can rapidly harvest using up to eight brush-row units on a minimum of 76 cm (30 in.) row spacing. Many of the harvesters are equipped with field cleaners on the harvester to remove harvested burs and sticks.

Module Builder

As mechanical cotton harvesting capacity and speed increased, seed cotton handling and storage became increasingly important. These changes in cotton harvesting capability forced changes downstream from the harvester, and to quote a prominent gin engineer, "Another result of mechanical harvesting is in itself a major development—the introduction of the seed cotton module system for bringing the harvested cotton to the gin" (Van Doorn, 1999). The cotton module system provides economical reservoirs where harvested cotton may be safely stored when it cannot be ginned immediately, permitting the harvesting operation to proceed independently of ginning. Before cotton modules were developed, cotton was usually stored in trailers or

Figure 5. Cotton wagon line up in 1930s.

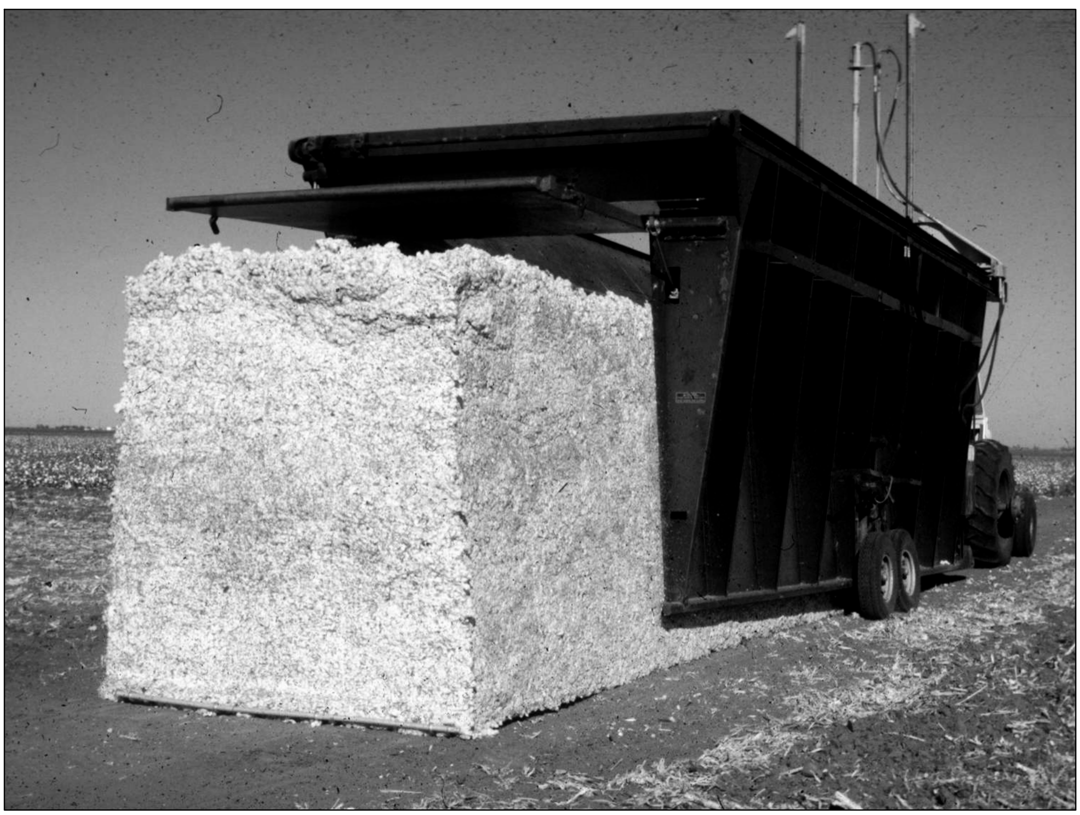


Figure 6. Early cotton module and module builder.

wagons, which limited the amount of storage, restricting harvesting speed and timeliness (fig. 5). Gins were also designed with limited processing capacity, which caused extended seed cotton storage times. Delayed harvesting typically resulted in reduced quantity and quality of cotton due to wind and rain. Dumping seed cotton on turnrows and loading it onto trailers when they became available was also used to a limited extent.

Some farmers stored seed cotton on turnrows in special containers that could be loaded onto trucks because this process was more economical than buying additional trailers. In the late 1960s, the Arkansas cotton caddy was the first device to make a manually compacted, freestanding stack of harvested cotton used for both storage and transport. The cotton caddy had a roller bed trailer with sides of corrugated metal that created freestanding stacks of cotton on a pallet and placed them on the field turnrow. The caddy was used to transport the stacks to the gin by winching them back into the trailer at a later date, thus keeping the sides for transport. The cotton ricker, used in more arid production regions, was a movable slip form equipped with a compacting chamber into which harvesters dumped seed cotton. As the ricker was filled, the seed cotton was compacted, and the cotton form was moved forward to create a continuous row of cotton along the turnrow for storage. When trailers became available, the cotton was loaded and transported to the gin.

In 1971, Texas A&M University and Cotton Incorporated developed a new system for storing and handling seed cotton. This system has since become known as the cotton module system for seed cotton handling and storage from the field to the gin (Wilkes and Jones, 1973). A cotton module is a freestanding stack of cotton created by dumping harvested material into a form known as a module builder. A module builder is equipped with a mechanism that compacts the harvested material to a density of about 192 kg m^{-3} (12 lb ft^{-3}), thus giving the stack integrity to be freestanding after the builder is removed (fig. 6).

In 1977, there were about 2,689 cotton gin plants in the U.S. that received most of their harvested seed cotton in cotton trailers. Today, almost all harvested cotton is placed into module builders, stored in cotton modules on the edge of the field, and transported to gins using specially built, self-loading trucks. The system provides for a predictable, manageable, and economical ginning operation. Most gins have module storage areas that facilitate all-weather access to modules for processing. The module storage system has decoupled ginning from harvesting, providing an economical and safe method of handling and storing seed cotton. ASABE Standard S392.2 reflects a recent update to the essential features and dimensions of a module builder. Most module builders are 9.8 m (32 ft) in length, can range from 2.21 to 2.30 m (7.25 to 7.54 ft) wide at the base, and can be 2.59 m (8.5 ft) tall. Transporter dimensions are also provided in the Standard.

More recently, increases in harvesting capacity, labor costs, and module hauling distances to the gin have resulted in new research and development on seed cotton storage and handling devices. Both John Deere and Case IH are developing pickers with on-board module formation and handling systems. The John Deere six-row picker uses a round module, a 2.4 m (8 ft) wide and 2.3 m (7.5 ft) diameter cylinder weighing about 2,268 kg (5,000 lb), that is wrapped in a plastic film. The picker can hold one round module in a cradle and one in the chamber. The Case IH cotton picker has an onboard module builder using a half-module 4.9 m (16 ft) long and weighing about 4,536 kg (10,000 lb). Both systems have advantages and disadvantages; each reduces the labor requirements during harvesting and transfers some of the harvesting cost to the ginning operations.

Gin Development

Table 1 gives ginning statistics in decade intervals for the past century ending in 2007. Many of the 27,592 gins in the U.S. in 1907 were very small, wooden construction, plantation gins whose development was described in the introduction above. However, starting about 1884 (Bennett, 1962), the newer more modern 1907 cotton gin plants resembled the gin plant illustrated in figure 7. The latest 1907 gin plant had a single power source connected to a main line shaft from which all other machine components of the gin plant were driven. Seed cotton was pneumatically removed from cotton trailers and conveyed into the gin plant. The seed cotton was deposited into a mechanical distribution system that fed gin stand feeders, which metered the cotton into multiple saw gin stands. The ginned lint was then pneumatically collected from each individual gin stand and batch conveyed to the press condenser. Conveying air and fiber were separated at the condenser, and the fiber dropped into one side of a double-box bale press. A mechanical tramper tramped the cotton fiber into the box until full. Once full, the press was turned to put the full box either under or over a pressing ram to compress the cotton into its final bale form. The bale was tied with restraining bands and removed from the press. At the same time, the other empty box rotated under the filling tramper and the cycle was repeated. This basic gin system cycle is still being used today in 21st century ginning facilities. The average production rate for a 1907 saw gin stand was probably around one bale of cotton per stand per hour, while a modern saw gin stand can exceed 15 to 20 bales of cotton per stand per hour. What changed from the 27,592 gins in 1907 to the 835 gins in the 2007 season was not only average bale production but everything from cotton production and harvesting methods to the handling and conditioning components of the ginning system itself.

It is important to remember that all cotton in 1907 was hand picked by carefully (relative to machine harvesting) removing the seed cotton locks from the open boll manually and leaving everything else on the plant. The cost and availability of harvesting labor was such that pickers would

Table 1. U.S. cotton ginning statistics 1907-2007.

Crop Year	U.S. Cotton Production (bales × 1000)	U.S. Cotton Gins (number)	Average Bale Production by Gin
1907	11,106	27,592	402
1917	11,284	19,975	564
1927	12,956	14,845	873
1937	18,237	12,838	1,420
1947	11,556	8,272	1,397
1957	10,867	6,349	1,712
1967	7,439	4,203	1,770
1977	14,018	2,689	5,213
1987	14,359	1,653	8,687
1997	18,301	1,153	15,872
2007	20,998	835	25,147

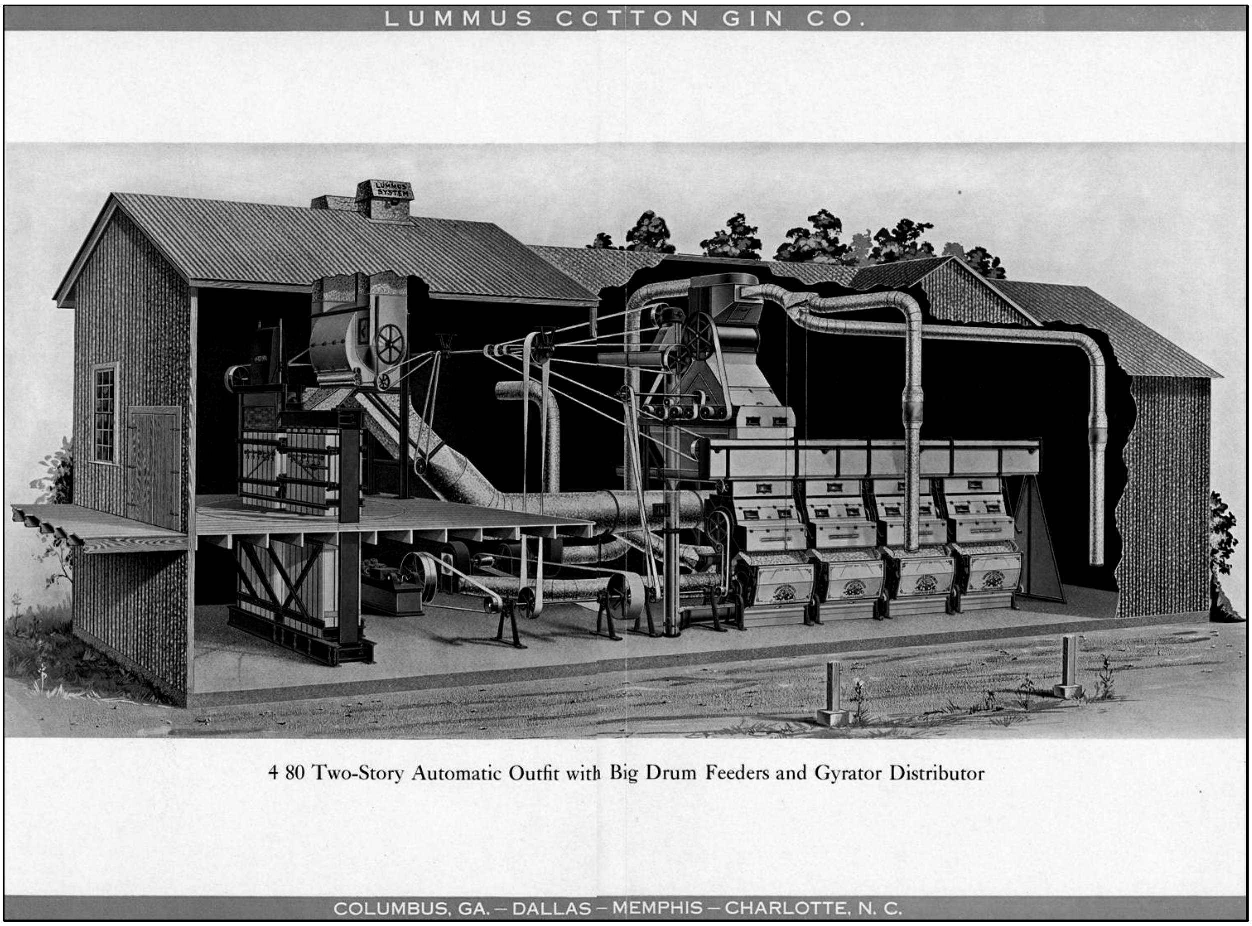


Figure 7. Typical 1907 cotton gin plant.

make several trips down the same row during the harvest season as bolls opened. As a result, the seed cotton that arrived at the gin in 1907 was relatively dry and contained very little trash. Very soon, however, labor costs rose and labor became less available, so that fewer trips were made through the field and whole bolls were more often plucked or snapped, bringing more trash to the gin in the harvested cotton. Since gin stand feeders were almost the only cleaners then used in gin plants, from 1910 to 1930 various manufacturers' almost continuously redesigned and added cleaning cylinders to their machines (Bennett, 1962; Authors, 2007). For example, in 1912, the John E. Mitchell Co. marketed a gin stand feeder that had two main cleaning cylinders and four other rotating members (fig. 8). By 1930 and eight different models later, the Mitchell feeder had four main cleaning cylinders and ten other rotating members (fig. 9). These multiple changes represented attempts by gin engineers to continuously improve the ginning system's ability to clean the trashier hand-harvested cotton that was being brought to the gin.

A significant addition to the cotton ginning system was made in 1932 by engineers from the USDA Ginning Laboratory in Stoneville, Mississippi, with the development of the "government tower drier" (Bennett, 1932, 1962). Figure 10 shows a 1930s gin plant with the tower drier added on the right side. The purpose of the drier, part of the cotton wagon unloading system, was to convey and dry seed cotton, thus improving cleaning prior to the gin stand. Other than the addition of the tower drier, the 1930s gin plant shown in figure 10 looks remarkably like the 1907 era gin plant shown in figure 7. The introduction of the "government tower drier" set off a whole series of engineering developments centering on seed cotton drying and cleaning during the 1930s. Companies such as Gullett, Murray, Boardman (fig. 11), Neverchoke, Lummus, Hardwicke-Etter, Continental, and Hinckley were very active in designing and supplying seed cotton driers, sometimes combined with cylinder cleaners, prior to World War II.

Some of the reduction in gin plant numbers from 27,592 in 1907 to 12,838 in 1937 (table 1) was probably due to the replacement of much older single-stand gin plants with multi-stand gin plants, as shown in figures 7 and 10. Another factor in the reduction of gins was undoubtedly the migration of the boll weevil from Brownsville, Texas, in 1892 and its rapid spread east to infest 1,553,993 square kilometers (600,000 square miles) of the mid-south and southeast cotton production area over the next 30 years, but that is not an engineering story (History, 2007; USDA, 1923; USBAE, 1951).

World War II temporarily slowed or stopped the introduction of new gin engineering technology, but following the end of the war, the next major engineering change was the introduction of the cotton picker. Few cotton pickers were manufactured during the war, but by 1947 cotton pickers were in mass production. In 1947, only 2% of the cotton in the U.S. was machine picked; by 1971, about

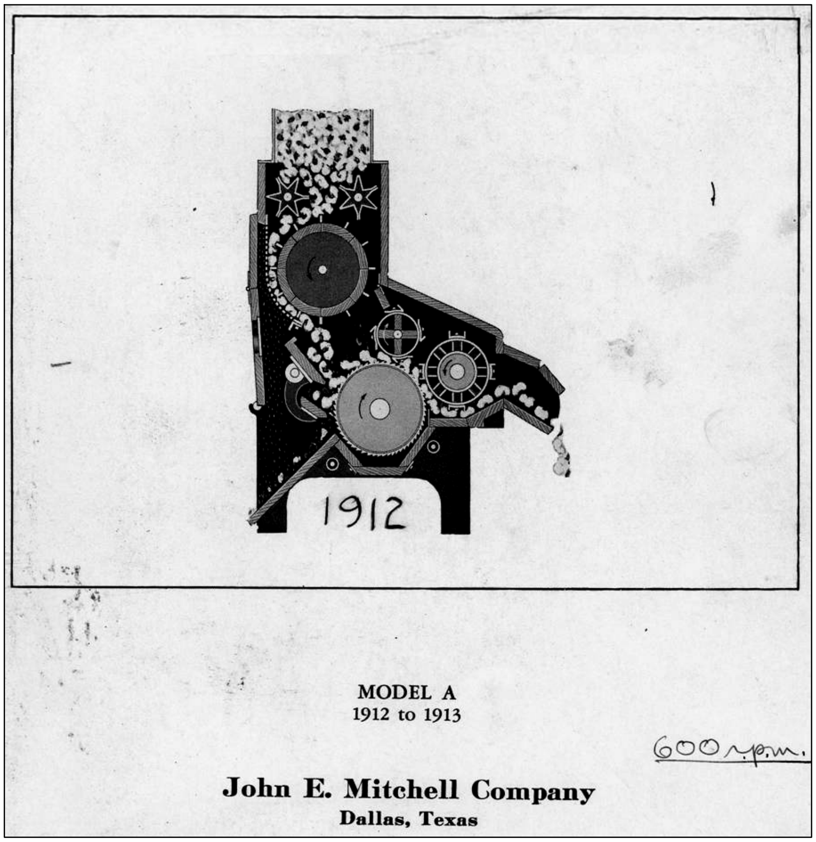


Figure 8. A 1912 gin stand feeder.

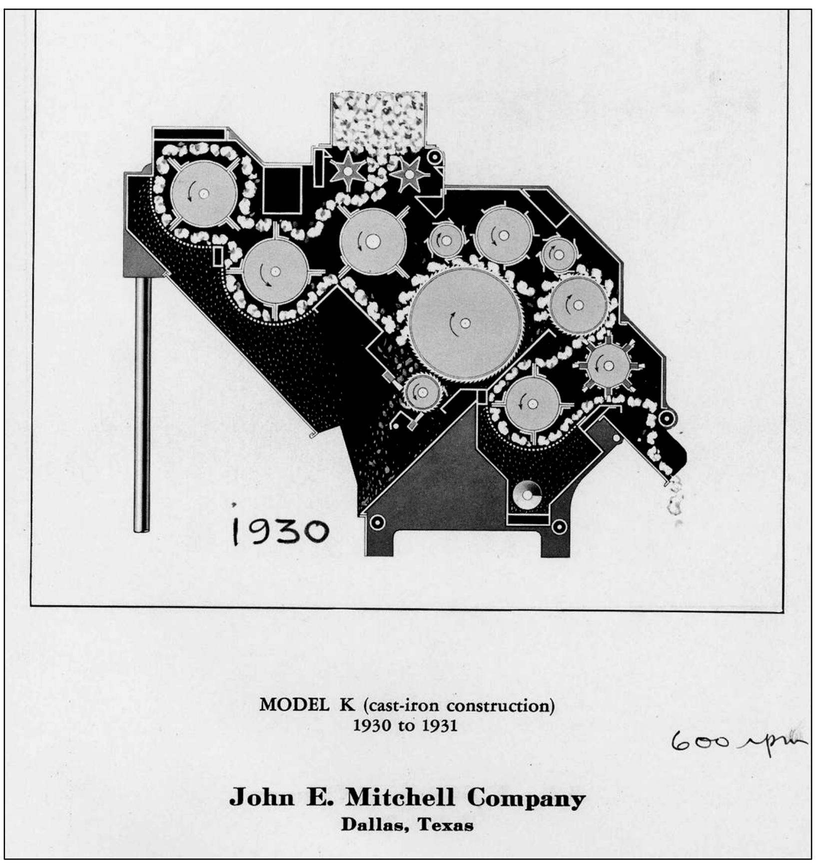
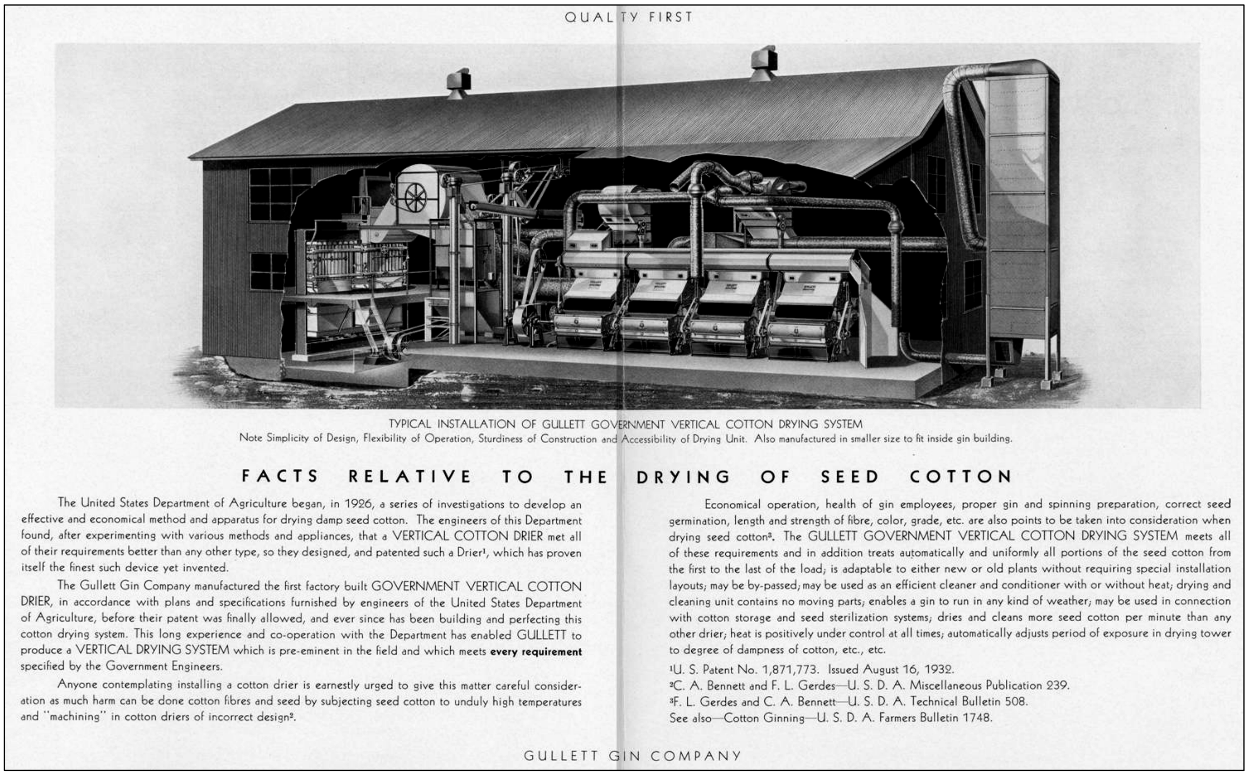


Figure 9. A 1930 gin stand feeder.



QUALITY FIRST

TYPICAL INSTALLATION OF GULLETT GOVERNMENT VERTICAL COTTON DRYING SYSTEM

Note Simplicity of Design, Flexibility of Operation, Sturdiness of Construction and Accessibility of Drying Unit. Also manufactured in smaller size to fit inside gin building.

FACTS RELATIVE TO THE DRYING OF SEED COTTON

The United States Department of Agriculture began, in 1926, a series of investigations to develop an effective and economical method and apparatus for drying damp seed cotton. The engineers of this Department found, after experimenting with various methods and appliances, that a VERTICAL COTTON DRIER met all of their requirements better than any other type, so they designed, and patented such a Drier[1], which has proven itself the finest such device yet invented.

The Gullett Gin Company manufactured the first factory built GOVERNMENT VERTICAL COTTON DRIER, in accordance with plans and specifications furnished by engineers of the United States Department of Agriculture, before their patent was finally allowed, and ever since has been building and perfecting this cotton drying system. This long experience and co-operation with the Department has enabled GULLETT to produce a VERTICAL DRYING SYSTEM which is pre-eminent in the field and which meets **every requirement** specified by the Government Engineers.

Anyone contemplating installing a cotton drier is earnestly urged to give this matter careful consideration as much harm can be done cotton fibres and seed by subjecting seed cotton to unduly high temperatures and "machining" in cotton driers of incorrect design[2].

Economical operation, health of gin employees, proper gin and spinning preparation, correct seed germination, length and strength of fibre, color, grade, etc. are also points to be taken into consideration when drying seed cotton[3]. The GULLETT GOVERNMENT VERTICAL COTTON DRYING SYSTEM meets all of these requirements and in addition treats automatically and uniformly all portions of the seed cotton from the first to the last of the load; is adaptable to either new or old plants without requiring special installation layouts; may be by-passed; may be used as an efficient cleaner and conditioner with or without heat; drying and cleaning unit contains no moving parts; enables a gin to run in any kind of weather; may be used in connection with cotton storage and seed sterilization systems; dries and cleans more seed cotton per minute than any other drier; heat is positively under control at all times; automatically adjusts period of exposure in drying tower to degree of dampness of cotton, etc., etc.

[1]U. S. Patent No. 1,871,773. Issued August 16, 1932.
[2]C. A. Bennett and F. L. Gerdes—U. S. D. A. Miscellaneous Publication 239.
[3]F. L. Gerdes and C. A. Bennett—U. S. D. A. Technical Bulletin 508.
See also—Cotton Ginning—U. S. D. A. Farmers Bulletin 1748.

GULLETT GIN COMPANY

Figure 10. Mechanized 1930s gin plant with a tower drier added on the right side.

Figure 11. An example of alternatives to the tower drier.

Figure 12. Moss-Gordin lint cleaner.

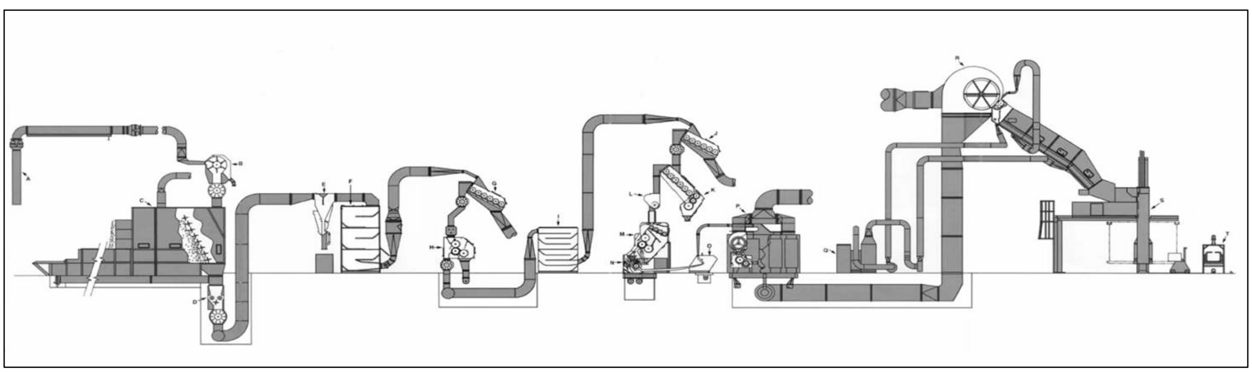


Figure 13. Modern cotton saw gin.

98% of the cotton in the U.S. was machine harvested. In the words of one prominent gin engineer, “In my opinion, by far the greatest impact on cotton since the invention of the cotton gin was the introduction of mechanical harvesting at the end of World War II. Mechanical pickers sent much more trash and moisture to the gin in the cotton. Consequently, gin machinery engineers frantically searched for ways to remove the trash and moisture” (Van Doorn, 1999). This search led to increased use and redesign of seed cotton cleaning and drying equipment, as well as another major change in ginning technology with the development of the saw-type lint cleaner.

Until the development of the mechanical harvester, most cotton cleaning technology had concentrated on cleaning seed cotton. Seed cotton cleaning alone was not sufficient to remove the greatly increased quantity of trash being brought to the gin by machine picking. By 1960, the Moss-Gordin Company was widely marketing their Super-Constellation saw-type lint cleaners (fig. 12). These and other similar machines had a significant impact on the harvesting, processing, and marketing of cotton. Saw lint cleaners were very aggressive cleaners and, combined with increased seed cotton cleaning and drying, were able to efficiently remove the extra trash that was being brought to the gin by mechanical harvesting. This more aggressive ginning system had a significant effect on the fiber quality and marketing of U.S. cotton. For example, in 1947, the average trash content of middlin' grade cotton (grade 31) (Authors, 2007) was about 5% by weight, as recognized for official trading purposes by the USDA Agricultural Marketing Service (AMS). By 1965, this same middlin' grade of cotton was recognized by AMS to contain about 2% trash by weight. This difference is a very significant change in ginned cotton quality as recognized by AMS.

Gin consolidation has continued up to 2006, with 835 currently active cotton gin plants that are processing more cotton than ever before. The modern saw gin looks a lot like figure 13. This gin has a module feeder followed by multiple stages of seed cotton cleaning and drying up to the modern high-speed gin stand(s) capable of ginning up to 20 bales per stand per hour. Efficient saw lint cleaning of the ginned fiber follows the gin stands before the cotton goes to the universal density bale press for baling. Once the cotton is baled, it is ready to be used in the domestic textile industry or loaded in containers and sent to any part of the world. The U.S. cotton industry produced over 20 million bales in 2006 and again produced approximately 18 million bales during the 2007/2008 season that were ginned and baled in modern high-capacity gin plants.

Conclusions

The story of cotton production in America has been a story of change, innovation, and increased productivity. From an engineer's perspective, these changes in the cotton system were driven by such things as the economic need to increase productivity, labor shortages, and fiber quality issues. All of these changes, large and small, have been the work of many unknown and a few known engineers who have supplied their skill and knowledge to the problem of producing a quality bale of U.S. cotton as efficiently and economically as possible. The fact that the U.S. cotton industry is currently producing as much or more cotton than it has at any time in its history and is doing it with a record minimum number of cotton gins and man hours is a testimony to the impact of engineering on the cotton industry. The next 100 years will have its technical challenges for the American cotton industry, but these challenges will be met and overcome by agricultural engineers just doing their jobs.

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